The Hyperspectral Environmental Suite (HES)

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SaTellite Applications and Research (STAR)

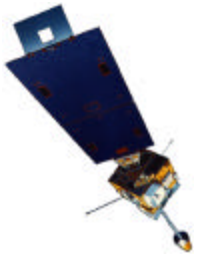
Advanced Satellite Products Team (ASPT)

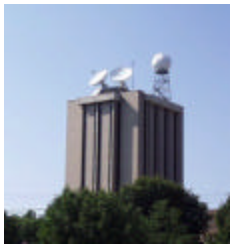
in collaboration with the

Cooperative Institute for Meteorological Satellite Studies (CIMSS)

Madison, WI

Satellite Direct Readout Users Conference for the Americas
12 December 2002





UW-Madison

Roadmap

- What is HES?
- Summary of Current GOES Sounder
- Review select high-spectral IR instruments
- Details of HES
- Summary

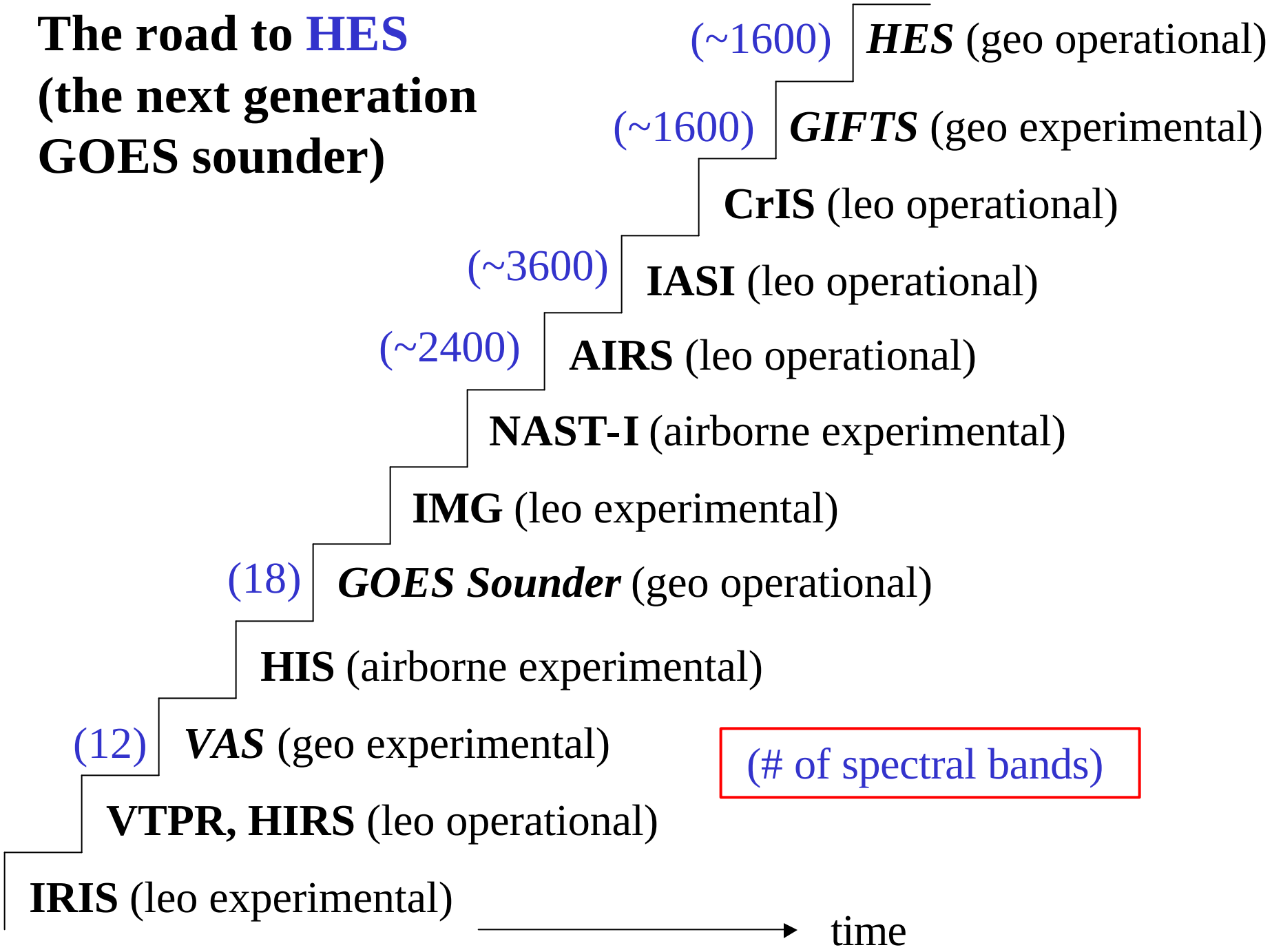
ABS=Advanced Baseline Sounder

HES=Hyperspectral Environmental Suite

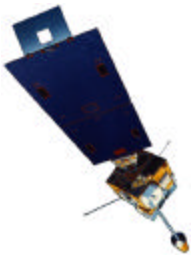
GOES Launch Planning *

Spacecraft	Availability Date	Planning Launch Date
GOES-N	Jan 2003	Jan 2003
GOES-O	Apr 2004	Apr 2005
GOES-P	Apr 2006	Apr 2007
GOES-R	Apr 2010	Apr 2012

*** Based on FY03 DOC Submission**


The road to HES
(the next generation
GOES sounder)
(~1600) HES (geo operational)
(~1600) GIFTS (geo experimental)
CrIS (leo operational)
(~3600) IASI (leo operational)
(~2400) AIRS (leo operational)
NAST-I (airborne experimental)
IMG (leo experimental)
(18) GOES Sounder (geo operational)
HIS (airborne experimental)
(12) VAS (geo experimental)
VTPR, HIRS (leo operational)
IRIS (leo experimental)
(# of spectral bands)
time

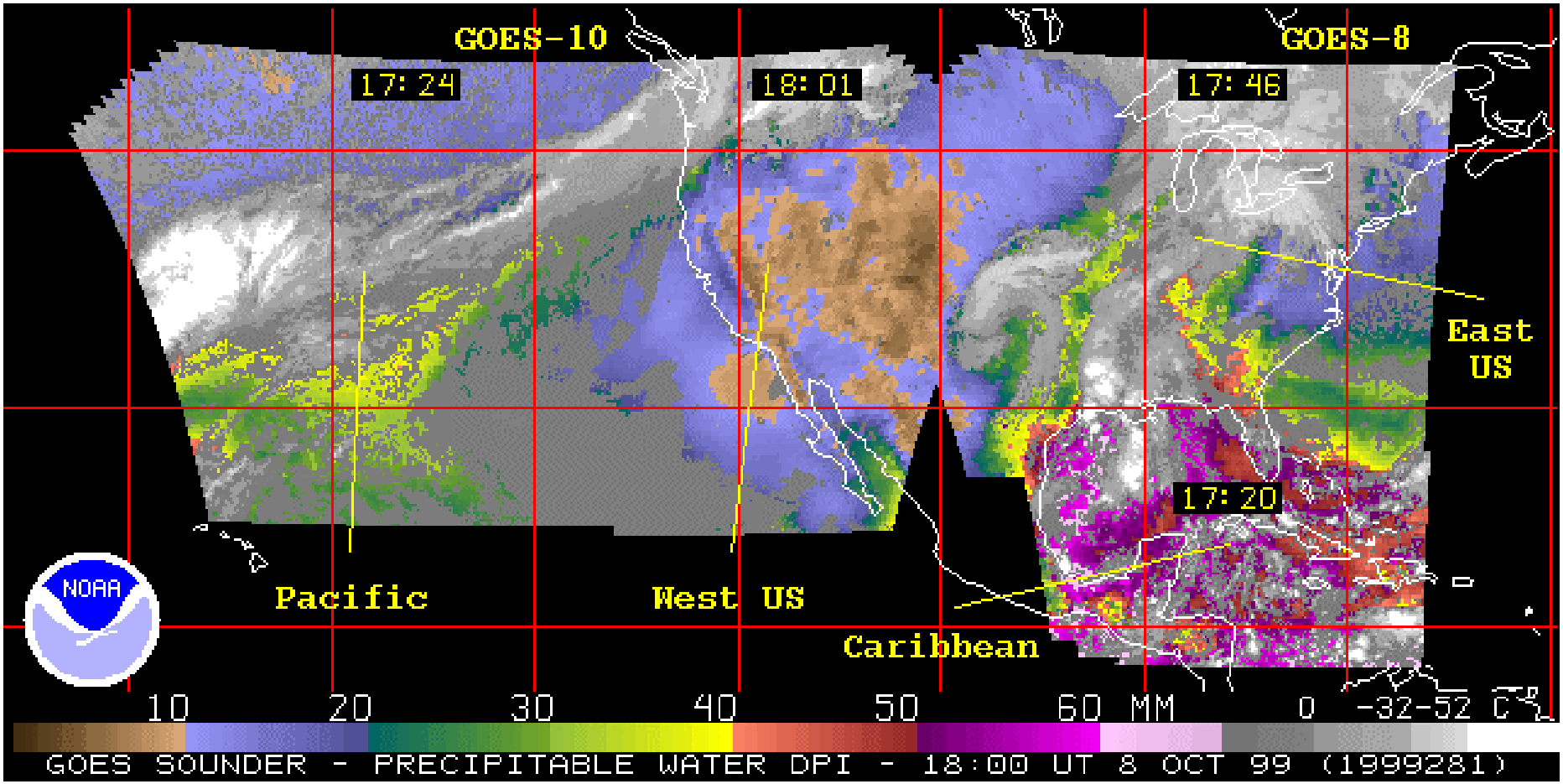
Future GOES



Future GOES will address all four key remote sensing areas

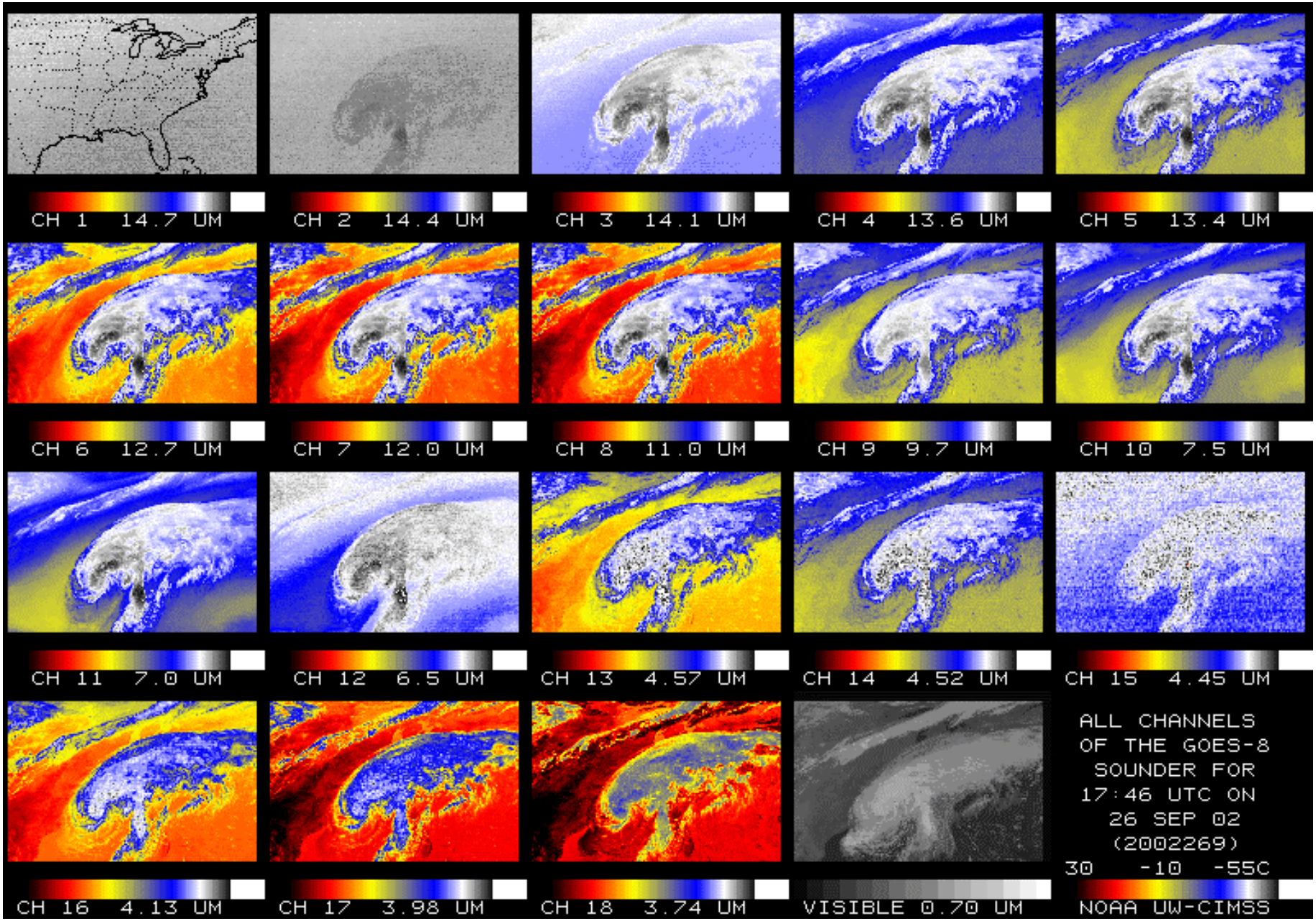
* spatial resolution – what picture element size is required to identify feature of interest and to capture its spatial variability;
* spectral coverage and resolution – what part of EM spectrum at each spatial element should be measured, and with what spectral resolution, to analyze an atmospheric or surface parameter;
* temporal resolution – how often does feature of interest need to be observed; and
* radiometric resolution – what signal to noise is required and how accurate does an observation need to be.

Current GOES Sounder has very limited geographical coverage
(e.g., no coverage in the Southern Hemisphere)

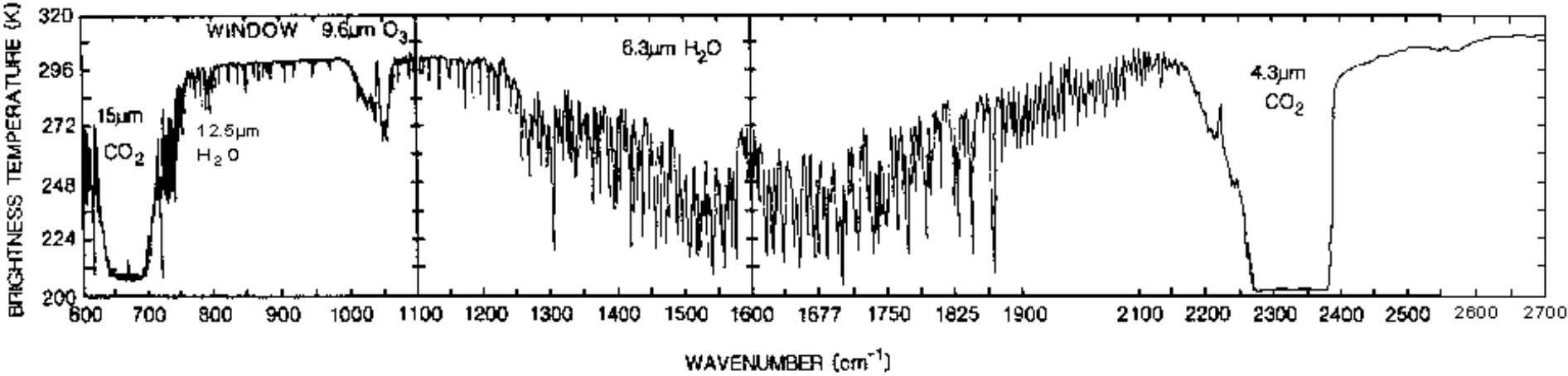


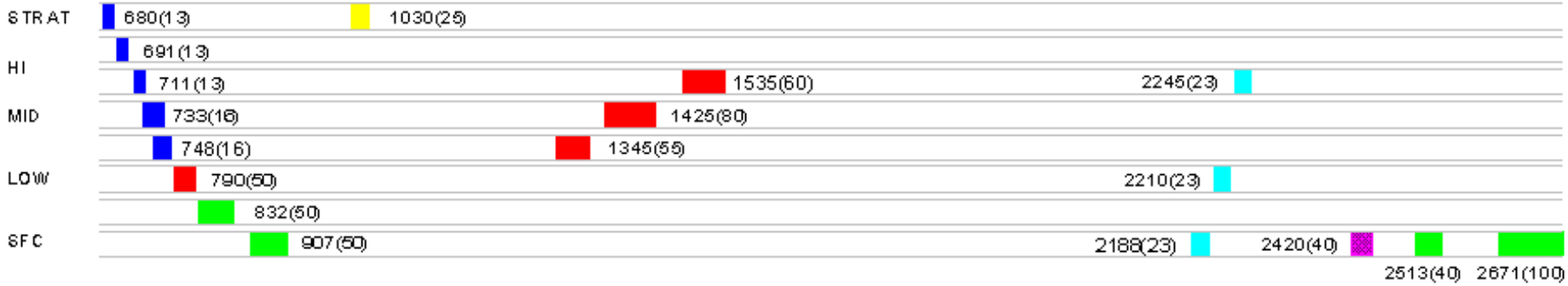
TPW example

GOES Sounder Spectral Bands: 14.7 to 3.7 um and visible



EARTH EMITTED SPECTRA

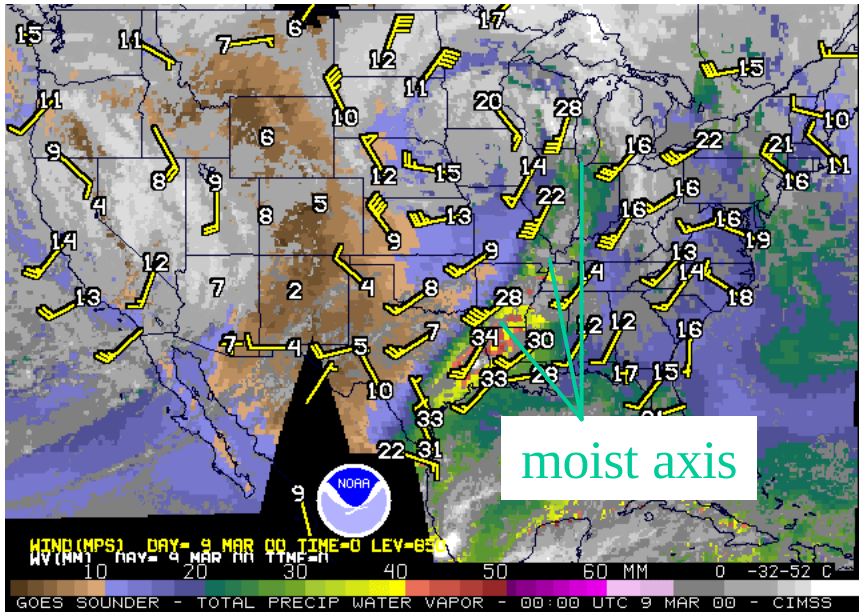


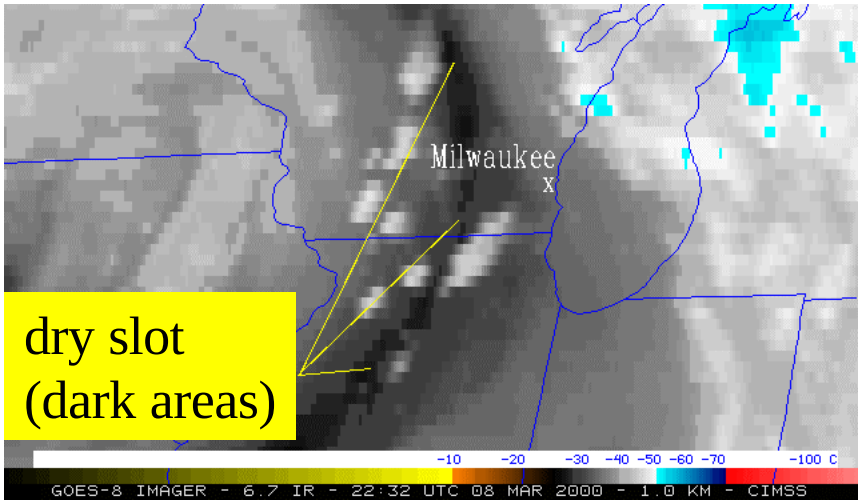


GOES-I SOUNDER SPECTRAL BANDS

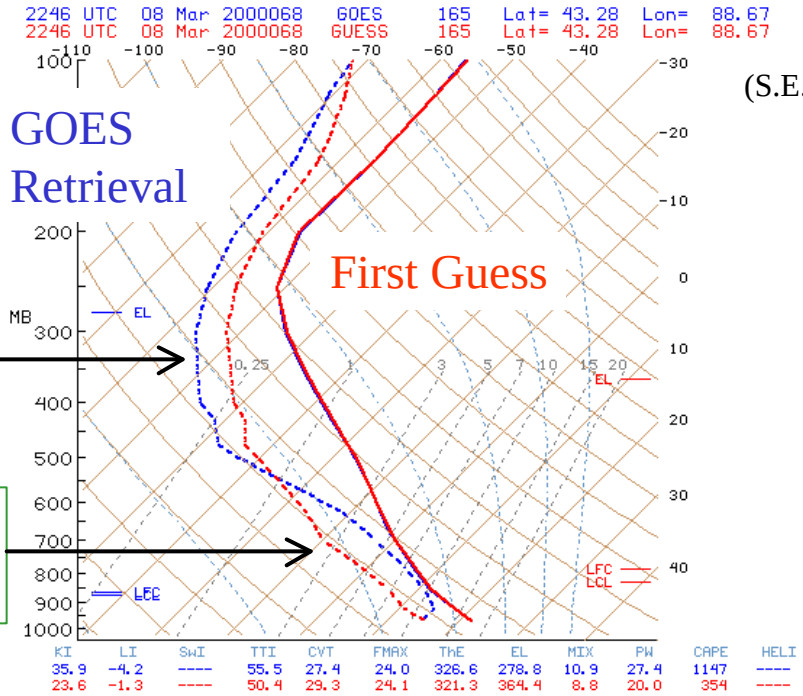
Record Earliest Tornado at Milwaukee, WI on 8 Mar 2000

- The GOES-8 Sounder monitors important precursors to the event.





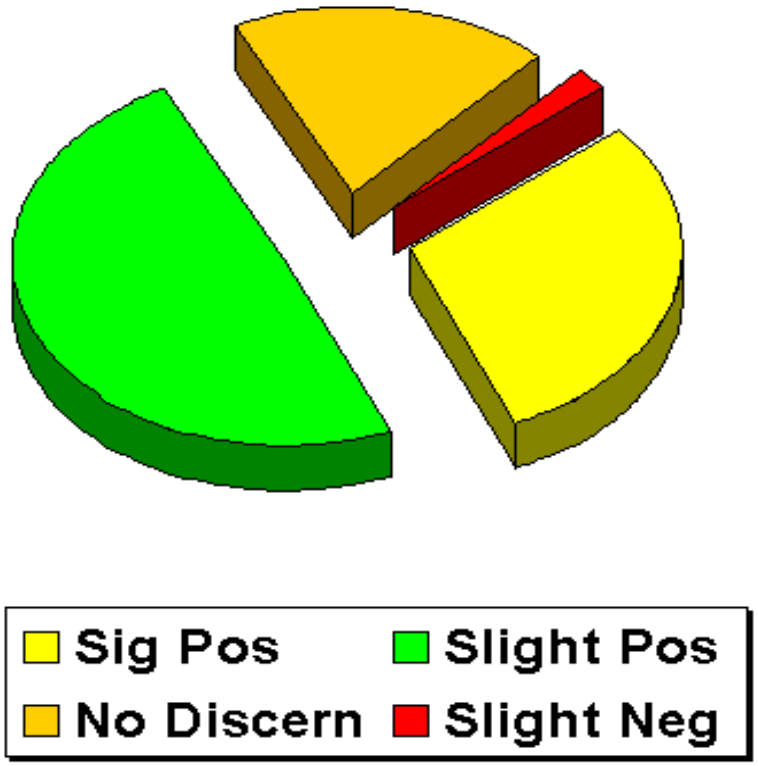
(S.E. WI)



Retrieval correctly subtracting moisture aloft (within the mid-level dry intrusion)

Retrieval correctly adding moisture in the lower levels (within the moist axis)

NWS Forecast Office Assessment of GOES Sounder Atmospheric Instability



Summer 1999 assessment of usefulness of hourly LI, CAPE, & CINH product for predicting location/timing of thunderstorms

There were 248 valid weather cases.
- Significant Positive Impact (30%)
- Slight Positive Impact (49%)
- No Discernible Impact (19%)
- Slight Negative Impact (2%)
- Significant Negative Impact (0)

Figure from the National Weather Service, Office of Services

AIRS

Instrument

- Hyperspectral radiometer with resolution of 0.5 – 2 cm^{-1}
- Extremely well calibrated pre-launch
- Spectral range: 650 – 2700 cm^{-1}
- Associated microwave instruments (AMSU, HSB)

Goals

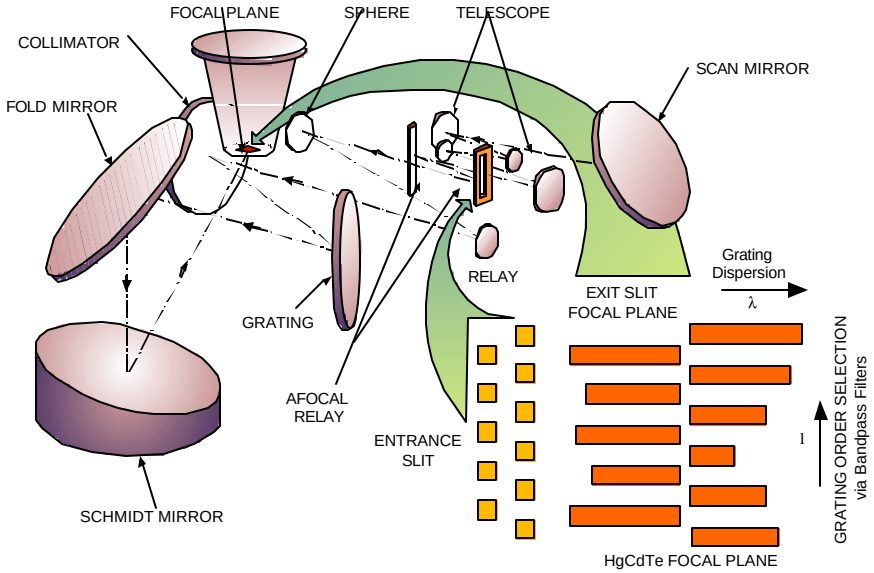
- Improve medium range weather forecasting and
- Provide long-term climate record via

  (1) hyperspectral infrared radiances

  (2) retrieved products such as **T(z), Q(z)**, O_3, CO, cloud properties, etc.
- Will greatly enhance soundings of temperature and humidity (1K/1km, 20%/2km)
- Has extremely "clean" SST channels in the 2600 cm^{-1} region
- Supports NOAA/NCEP's operational requirements. Data provided to assimilation centers.
- Precursor to future advanced high spectral resolution sounders (IASI, CrIS, GIFTS)

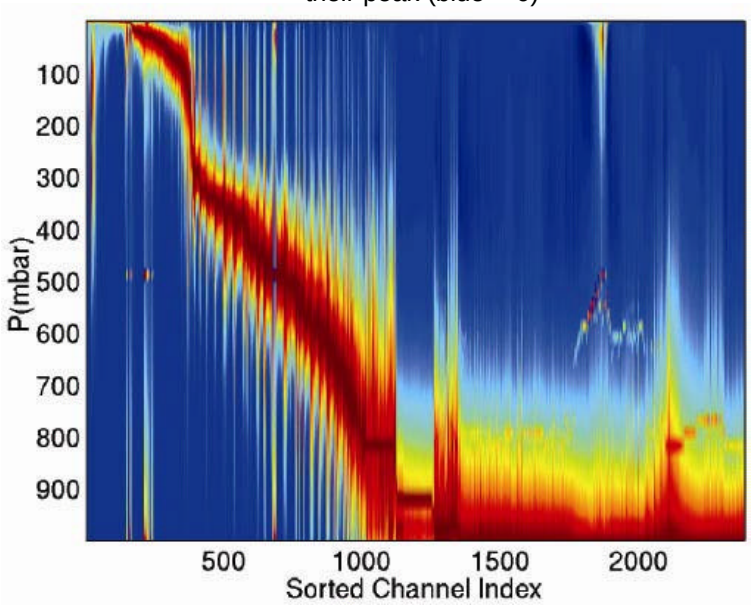
Design

- Grating Spectrometer passively cooled to 160K, stabilized to 30 mK
- PV and PC HdCdTe focal plane cooled to 60K with redundant active pulse tube cryogenic coolers
- Focal plane has **~5000 detectors**, 2378 channels. PV detectors (all below 13 microns) are doubly redundant. Two channels per resolution element (n/Dn = 1200)
- 310 K Blackbody and space view provides radiometric calibration
- Paralyene coating on calibration mirror and upwelling radiation provides spectral calibration
- NEDT (per resolution element) ranges from 0.05K to 0.5K

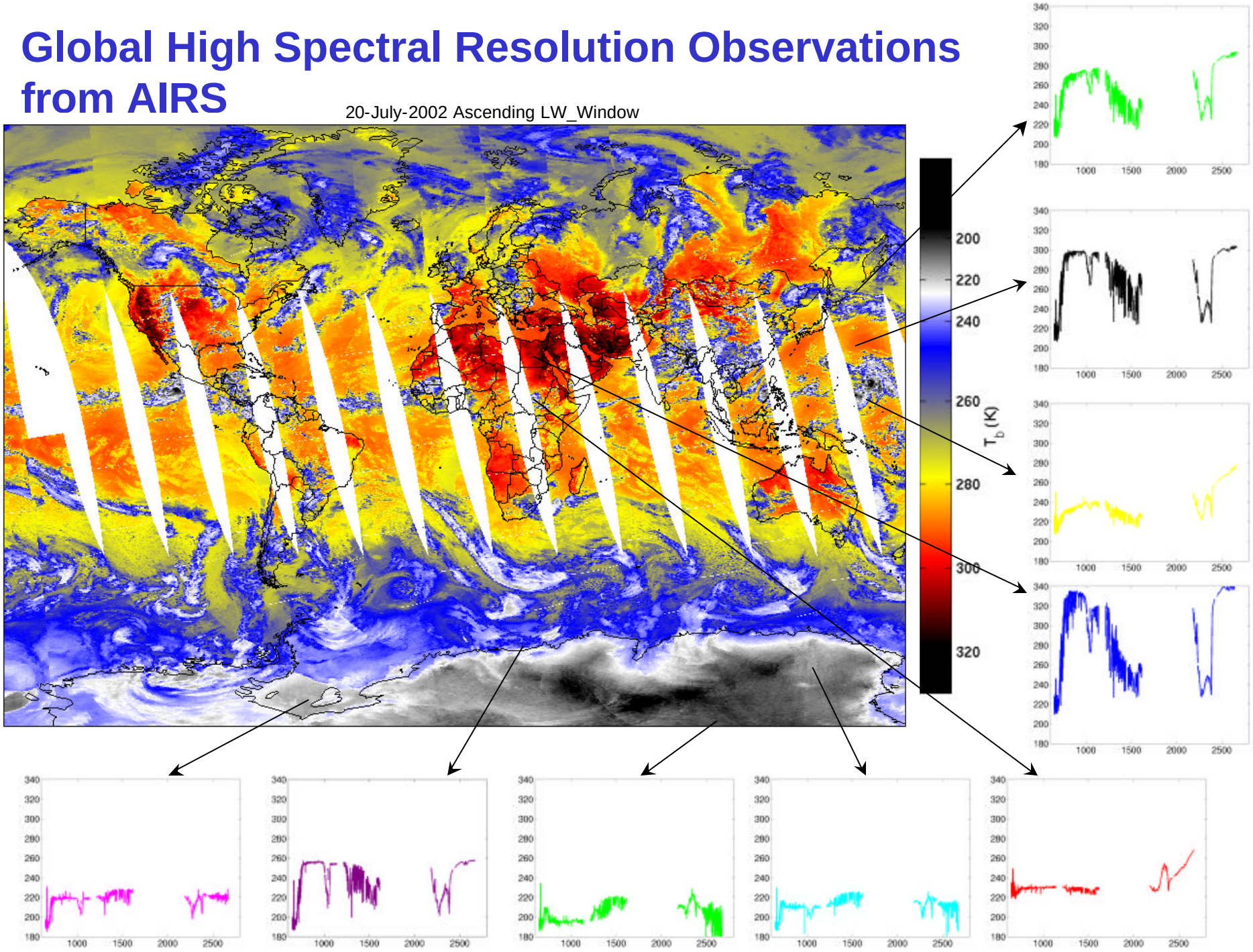


Spectral filters at each entrance slit and over each FPA array isolate color band (grating order) of interest

temperature weighting functions sorted by pressure of their peak (blue = 0)

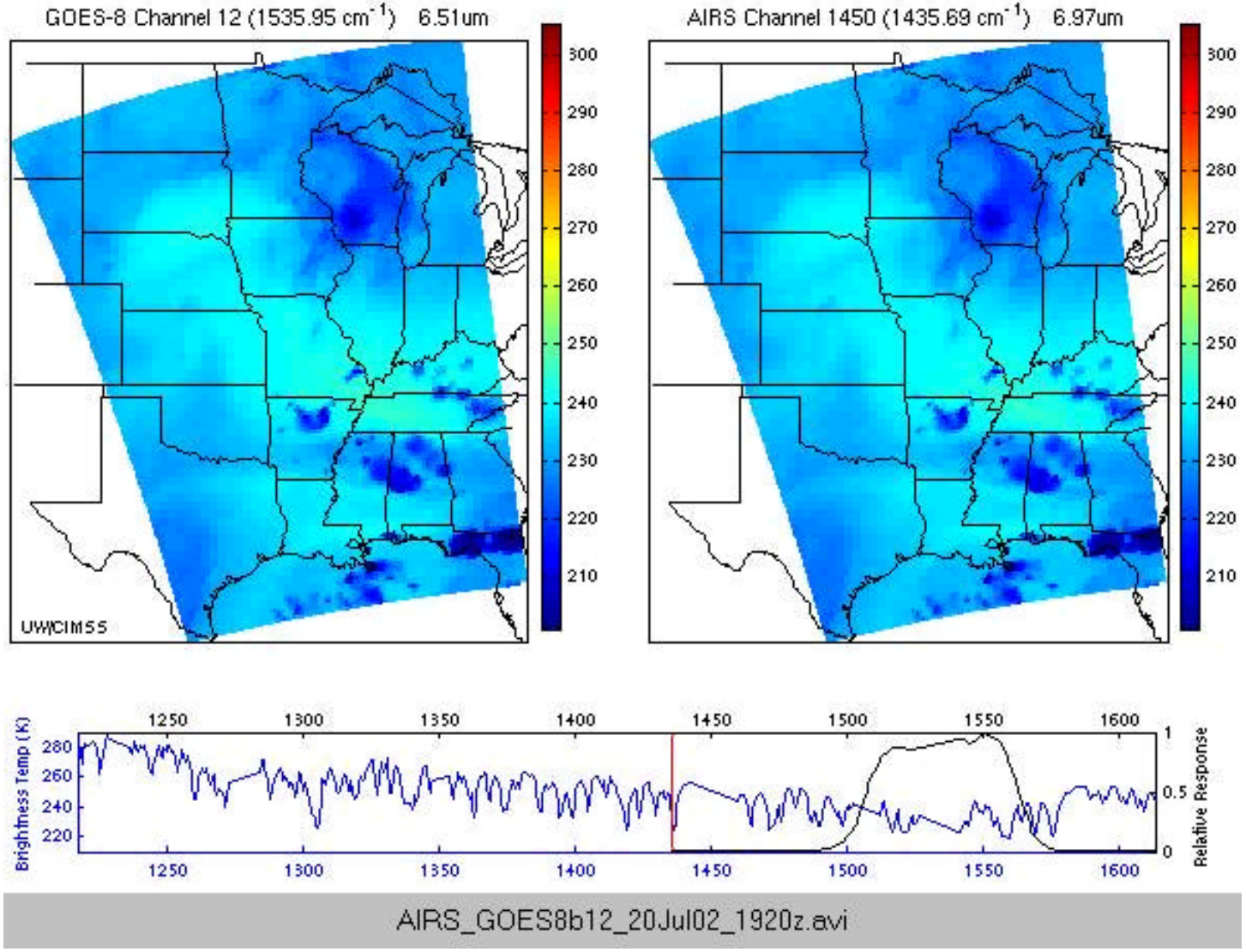


Global High Spectral Resolution Observations from AIRS



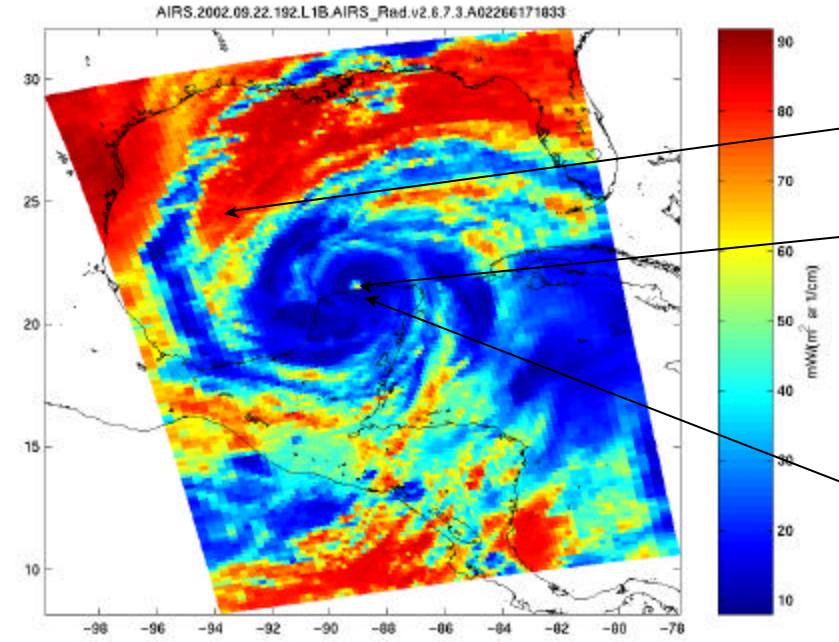
Water Vapor 6.7µm Band

(Low vs High Spectral resolutions

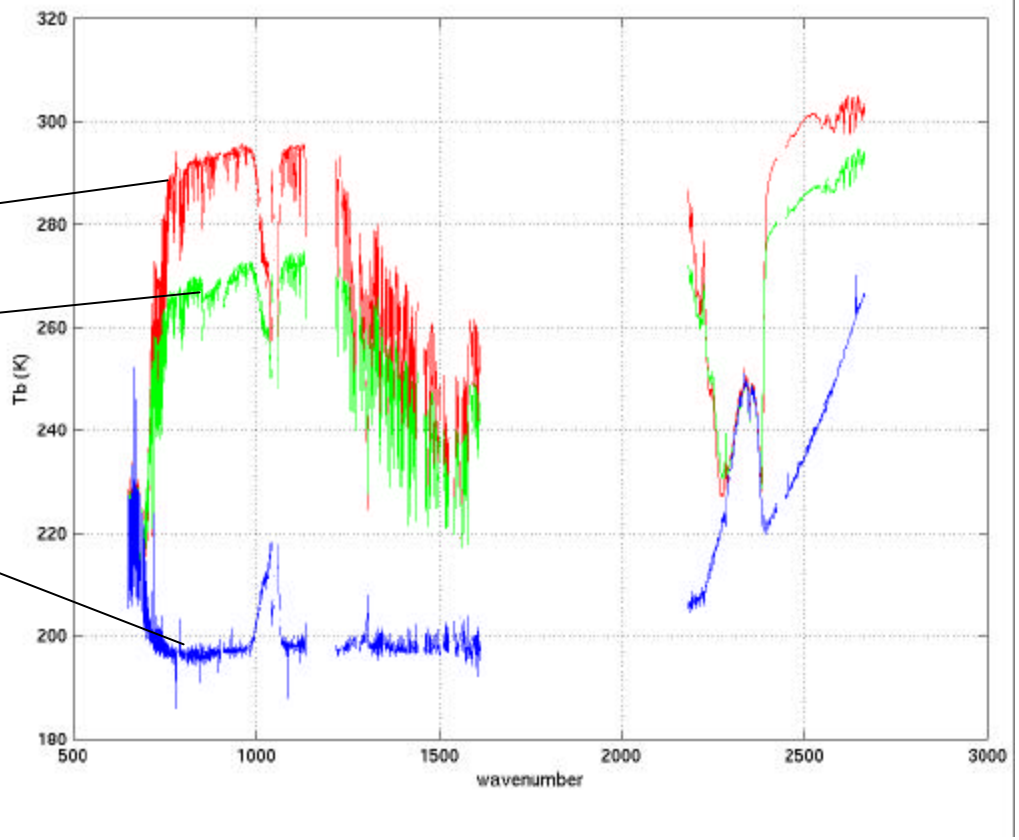


AIRS observations of tropical storm Isadore on 22 Sept 2002 @ ~19:12-19:18 UTC

~999 1/cm radiances

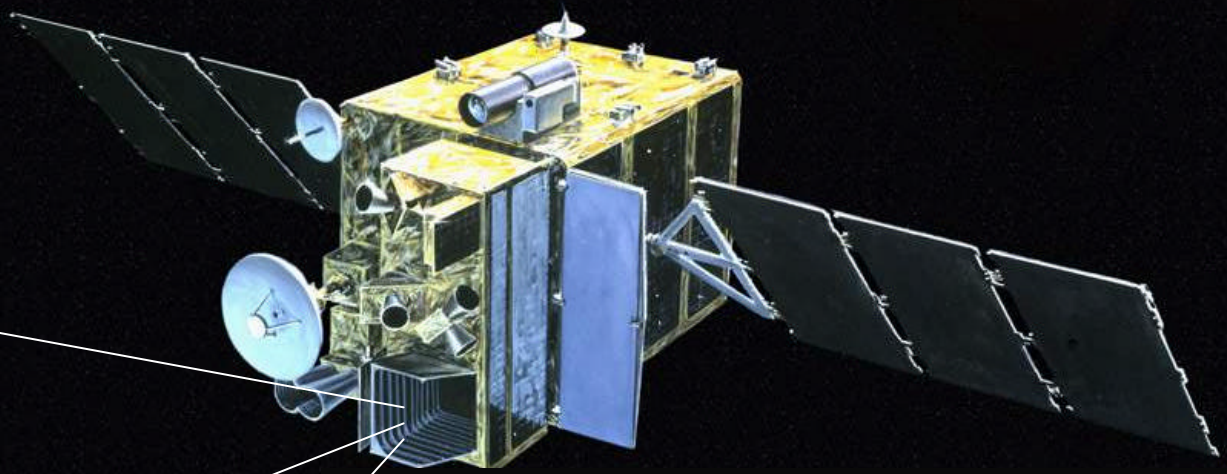


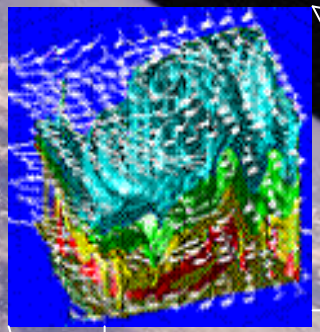
Brightness temperature spectra



GIFTS

New Technology for Atmospheric Temperature, Moisture, & Winds





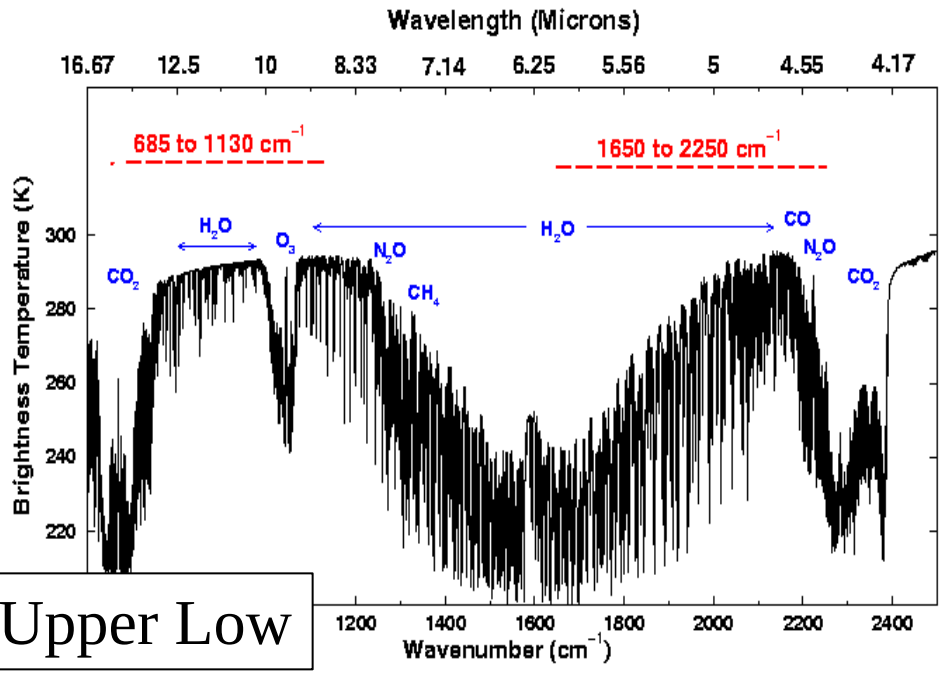
4-d Digital Camera:

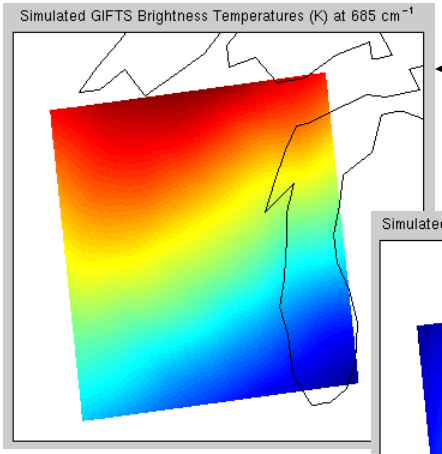
Horizontal: Large area format Focal Plane detector Arrays

Vertical: Fourier Transform Spectrometer

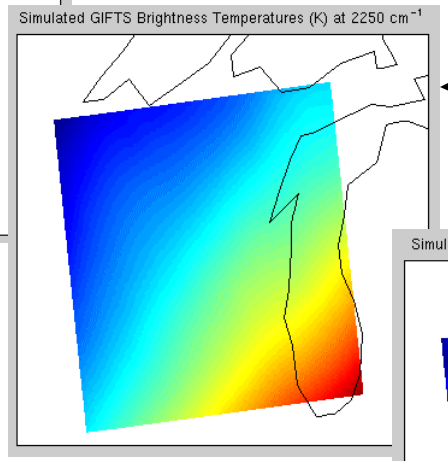
Time: Geostationary Satellite

GIFTS Spectral Imaging Simulation



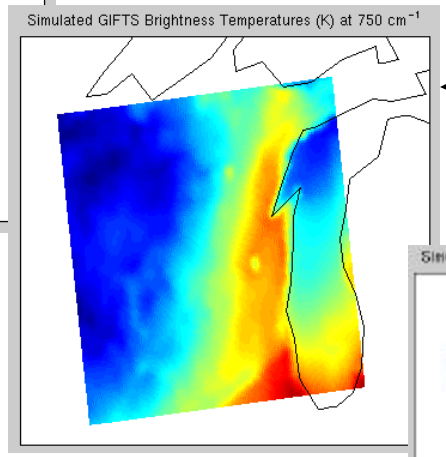


Upper High

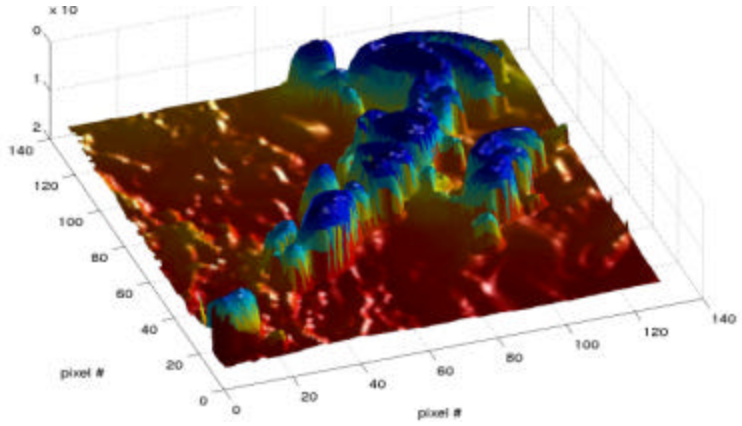


Upper Low

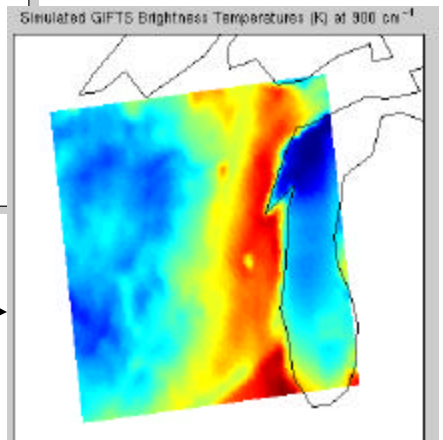
GIFTS 2 Bands Spectral Measurements



Middle



Surface



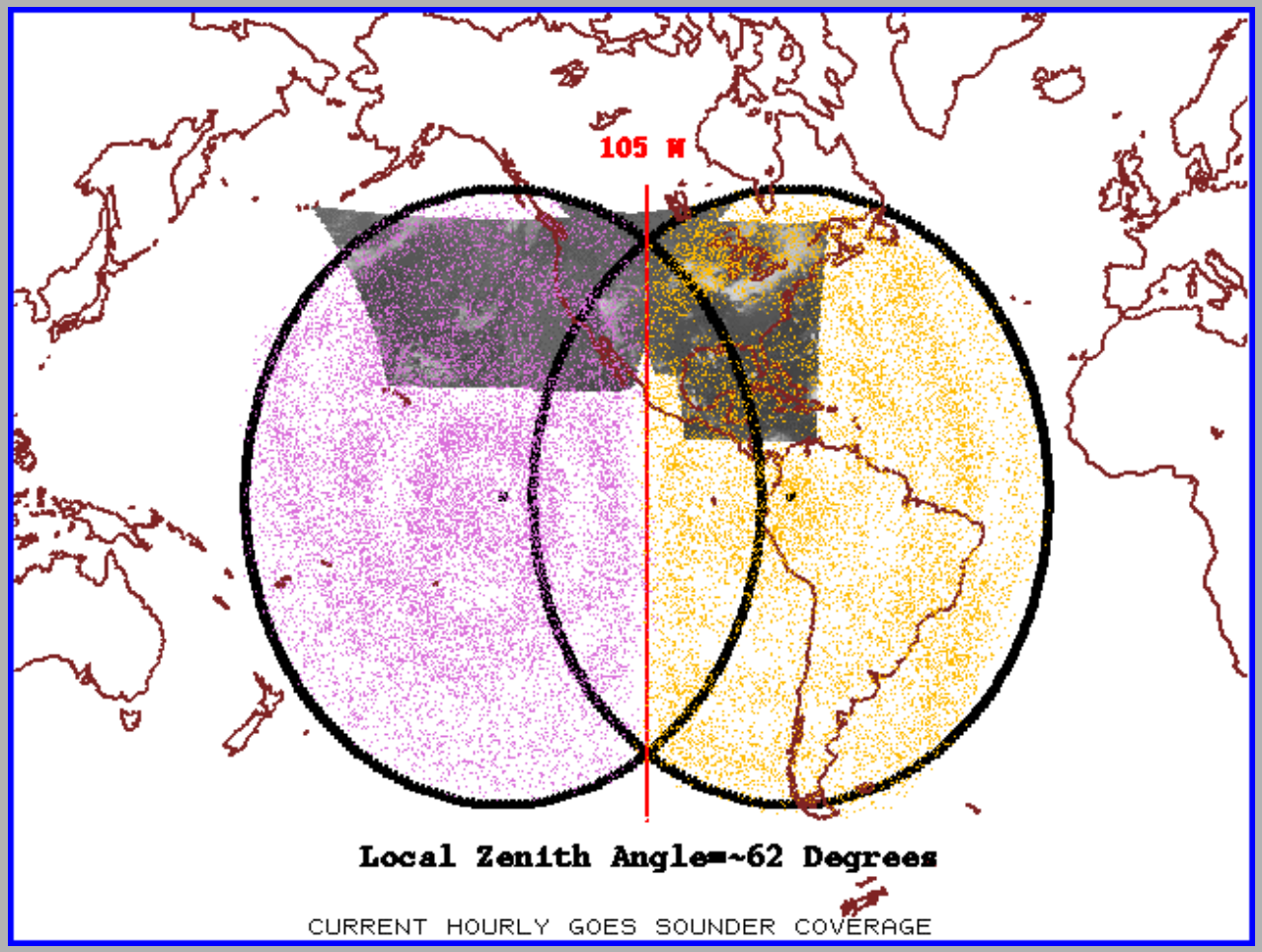
Sounder Comparison
(GOES-Current to ABS-Requirement)

	Current	Requirement
Coverage Rate	CONUS/hr	Sounding Disk/hr
Horizontal Resolution		
- Sampling Distance	10 km	10 km
- Individual Sounding	30-50 km	10 km
Vertical resolution	~3 km	1 km
Accuracy		
Temperature	2 deg. K	1 deg. K
Relative Humidity	20%	10%

NWS (and others) need an improved sounder

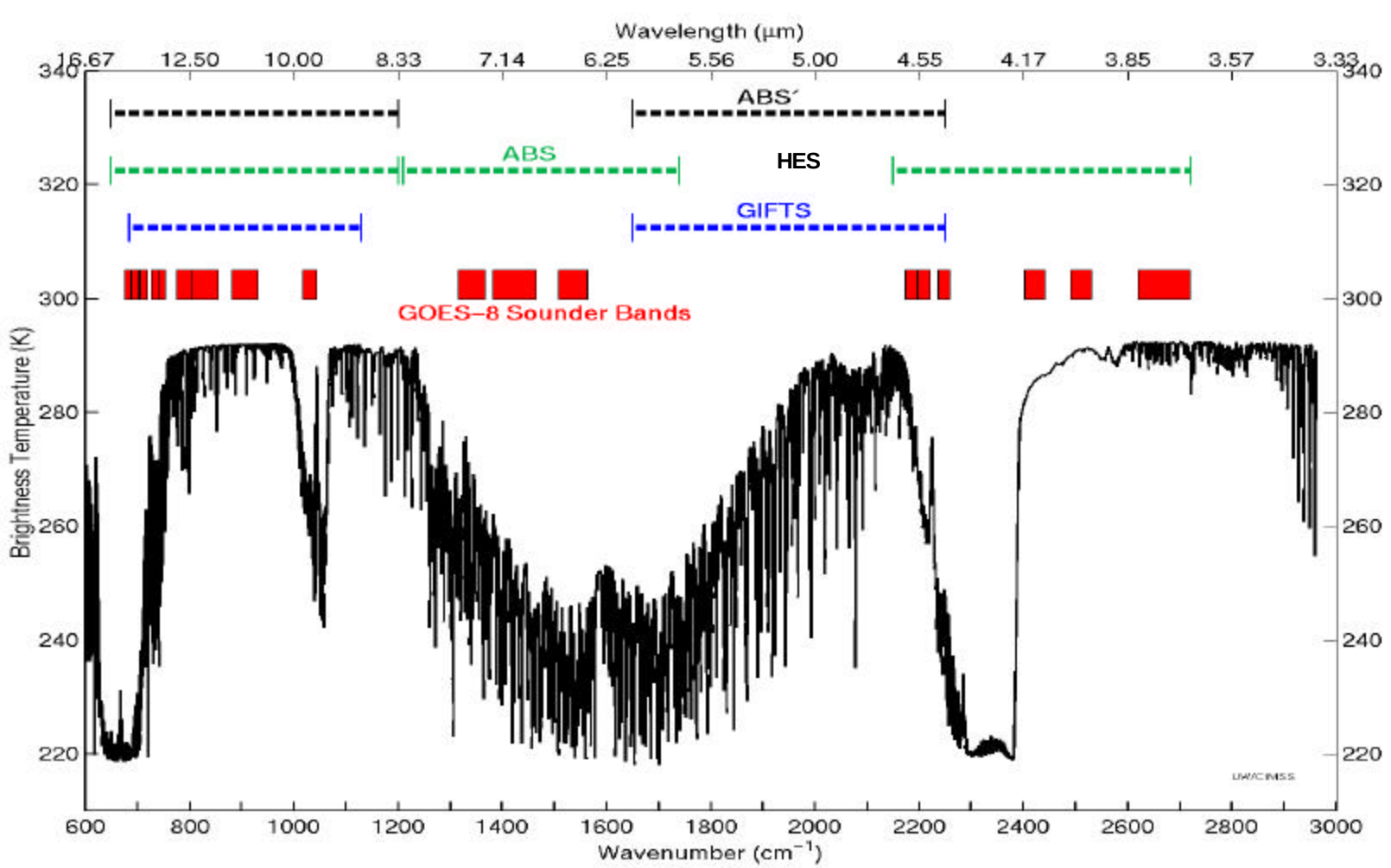
2012 launch

Spatial Coverage: Current vs. ABS



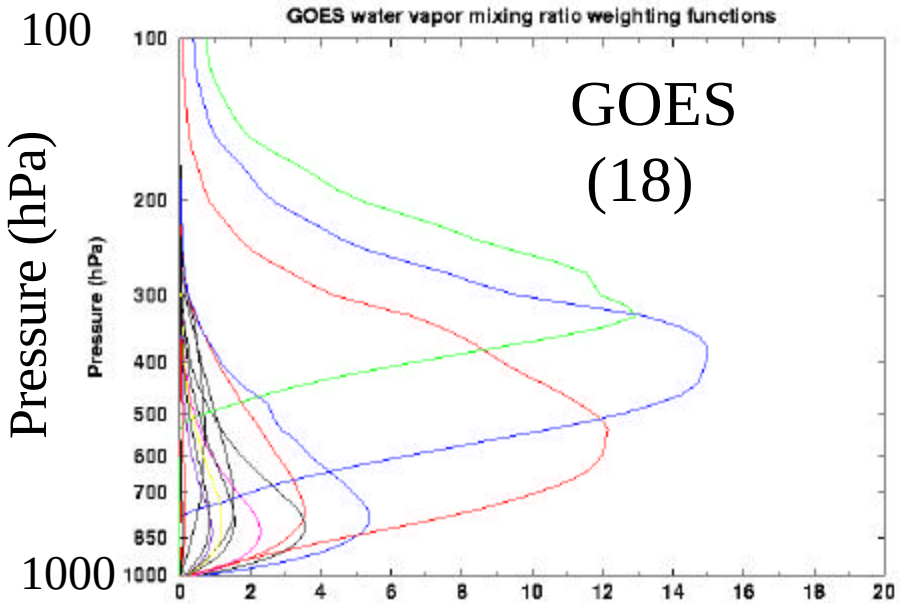
Areas within 62 degrees local zenith angle from GOES-East and GOES-West sub-satellite points are indicated. Threshold coverage rate calls for the 62 arc region, excluding half of over-lap, to be scanned each hour. Current GOES -E and -W sounder hourly coverage is also shown.

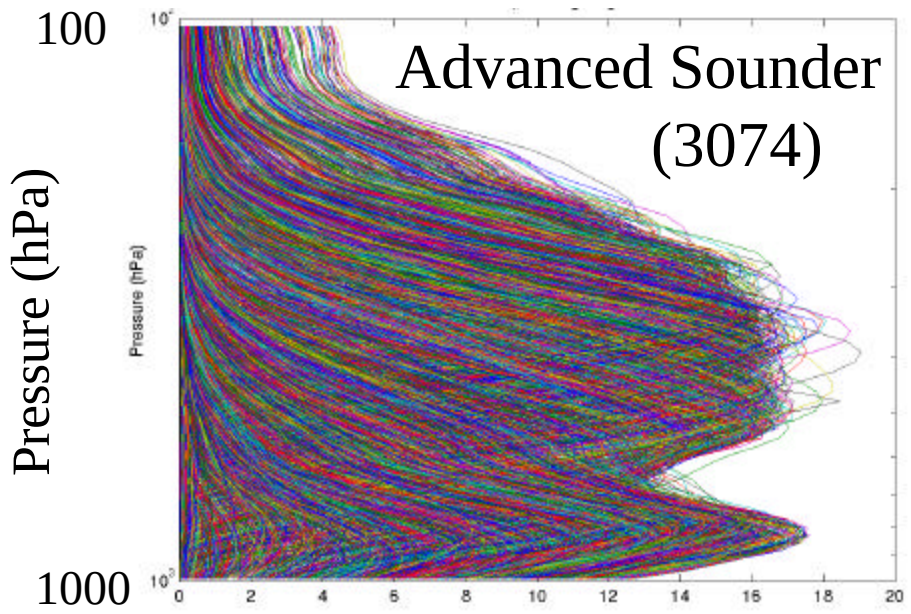
(UW/CIMSS)



Waveband (cm^{-1})	Wavelength (um)	Unapodized spectral resolution (cm^{-1})
650 – 1200	15.38 – 8.33	0.625
1650 – 2250	6.06 – 4.44	0.625

HES following GIFTS use of spectrum

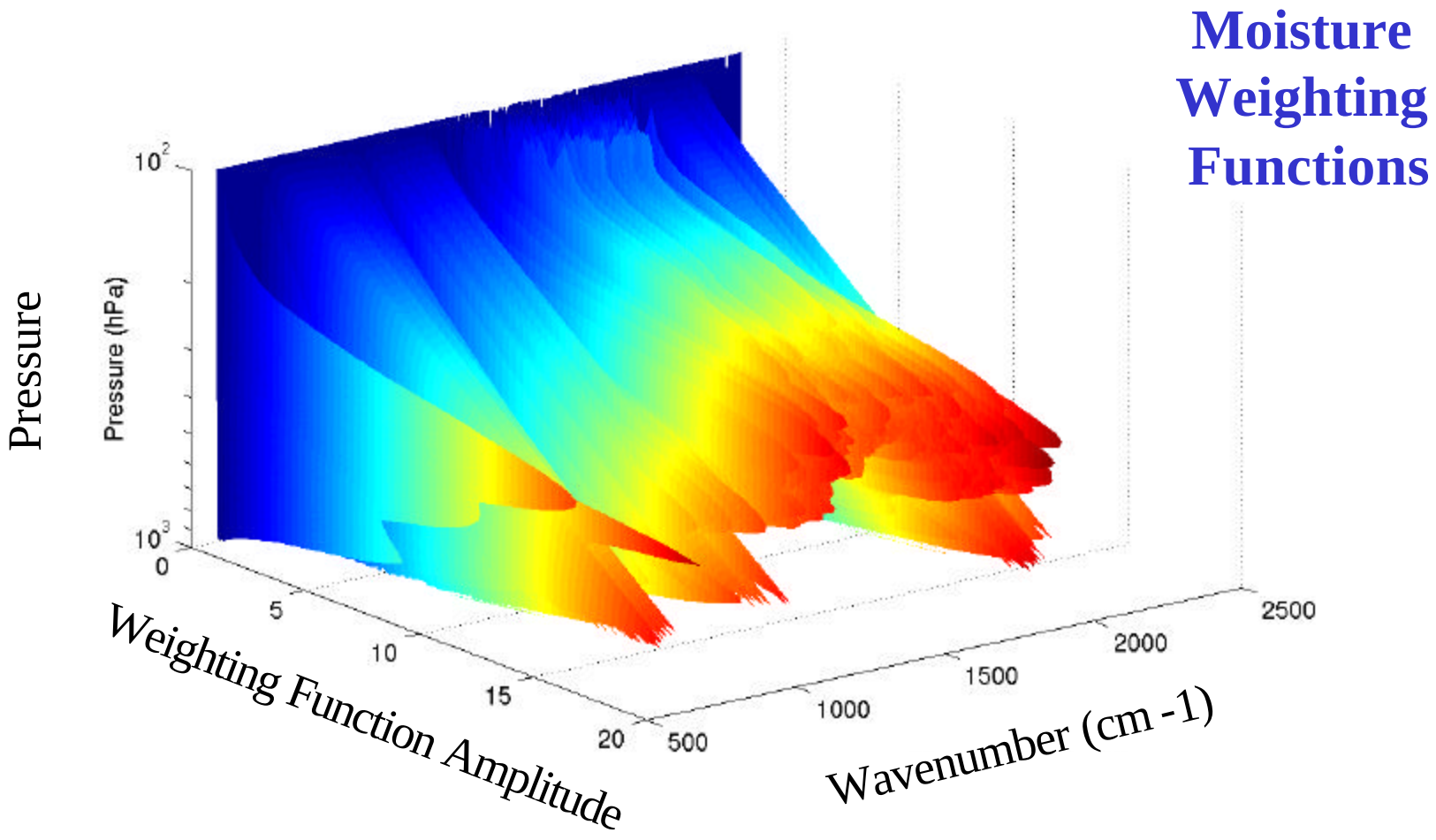




Moisture Weighting Functions

High spectral resolution advanced sounder will have more and sharper weighting functions compared to current GOES sounder. Retrievals will have better vertical resolution.

These water vapor weighting functions reflect the radiance sensitivity of the specific channels to a water vapor % change at a specific level (equivalent to dR/dlnq scaled by dlnp).

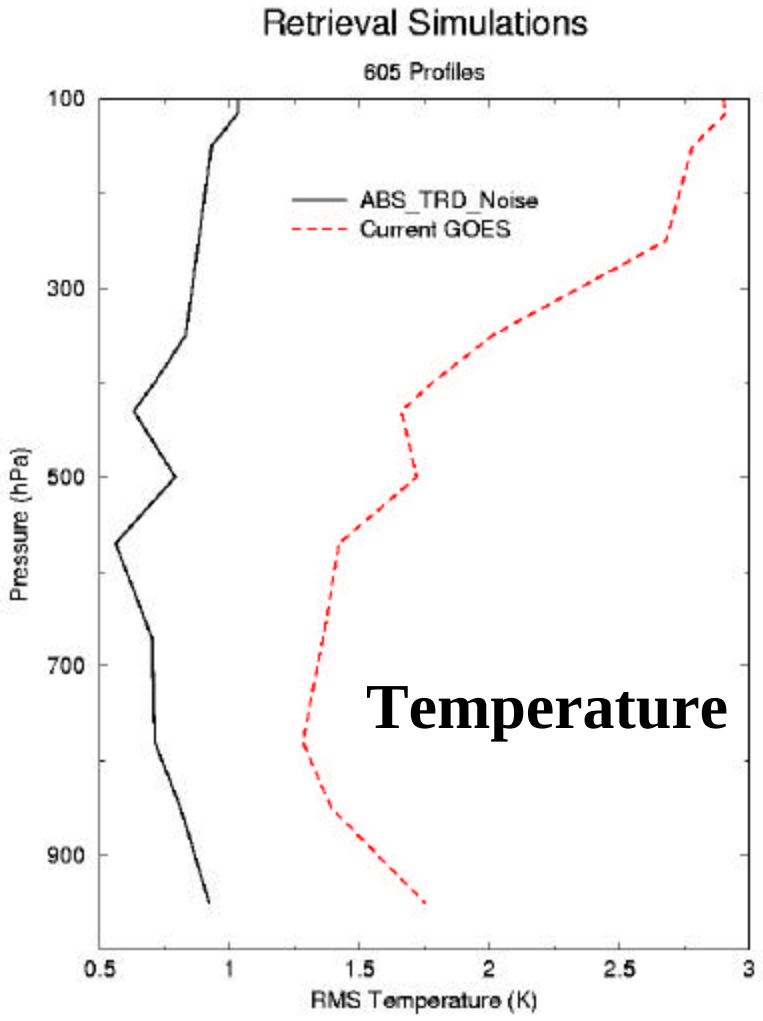


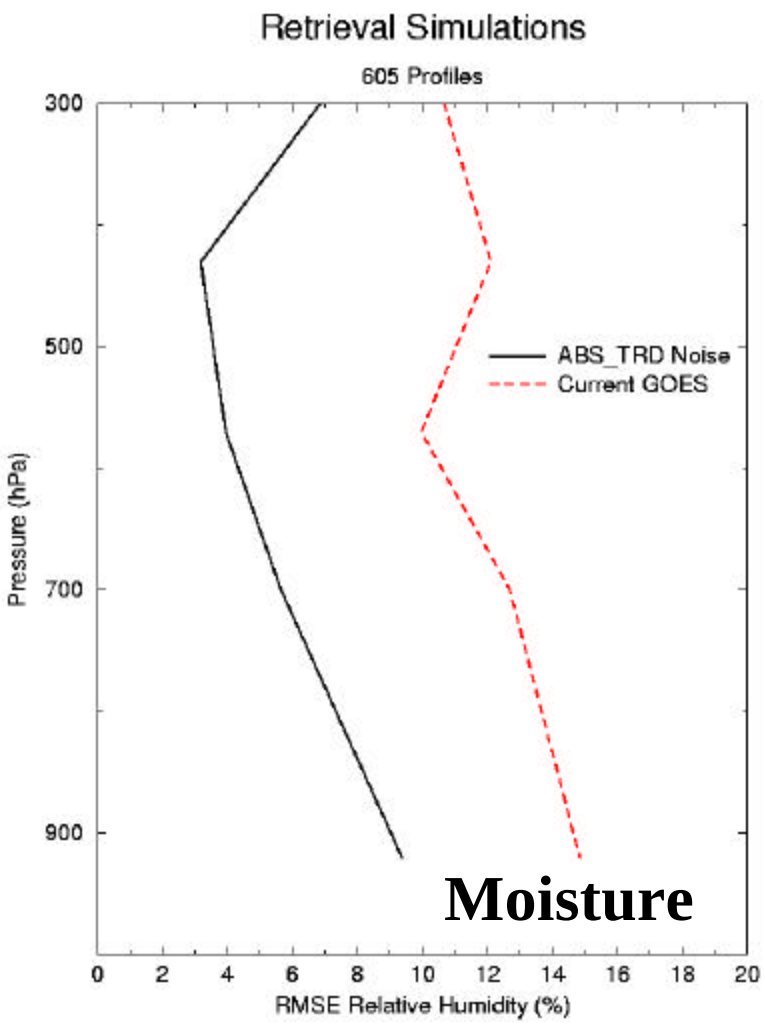
UW/CIMSS

The advanced sounder has more and sharper weighting functions

Simulations of Low vs High Spectral Resolution Retrievals

Geo-I gets <1 K rms for 1 km T(p) and <10% rms for 2 km RH(p)





Strategy is (1) use all channels in a regression first guess and then (2) use sub-set of channels for physical retrieval

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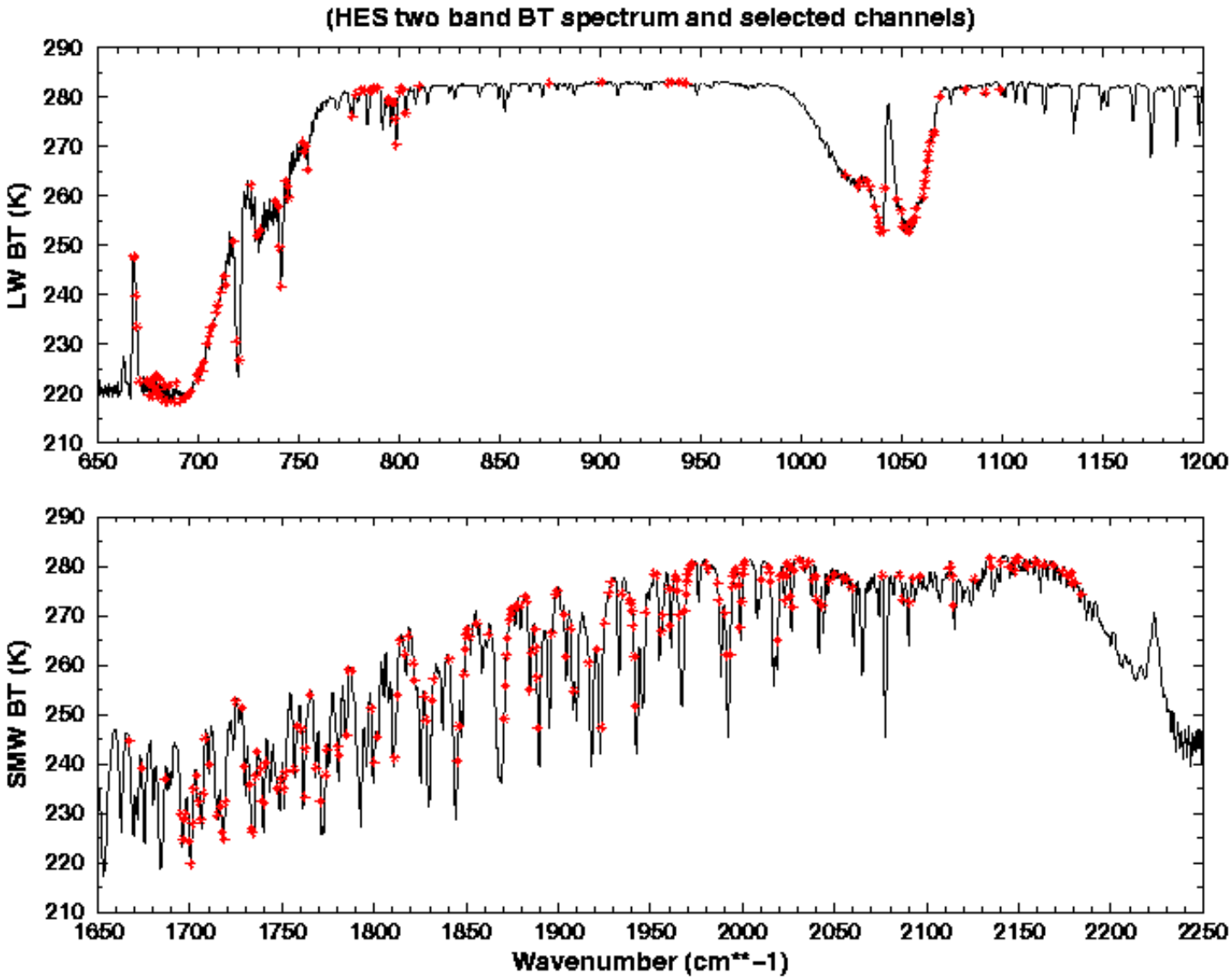
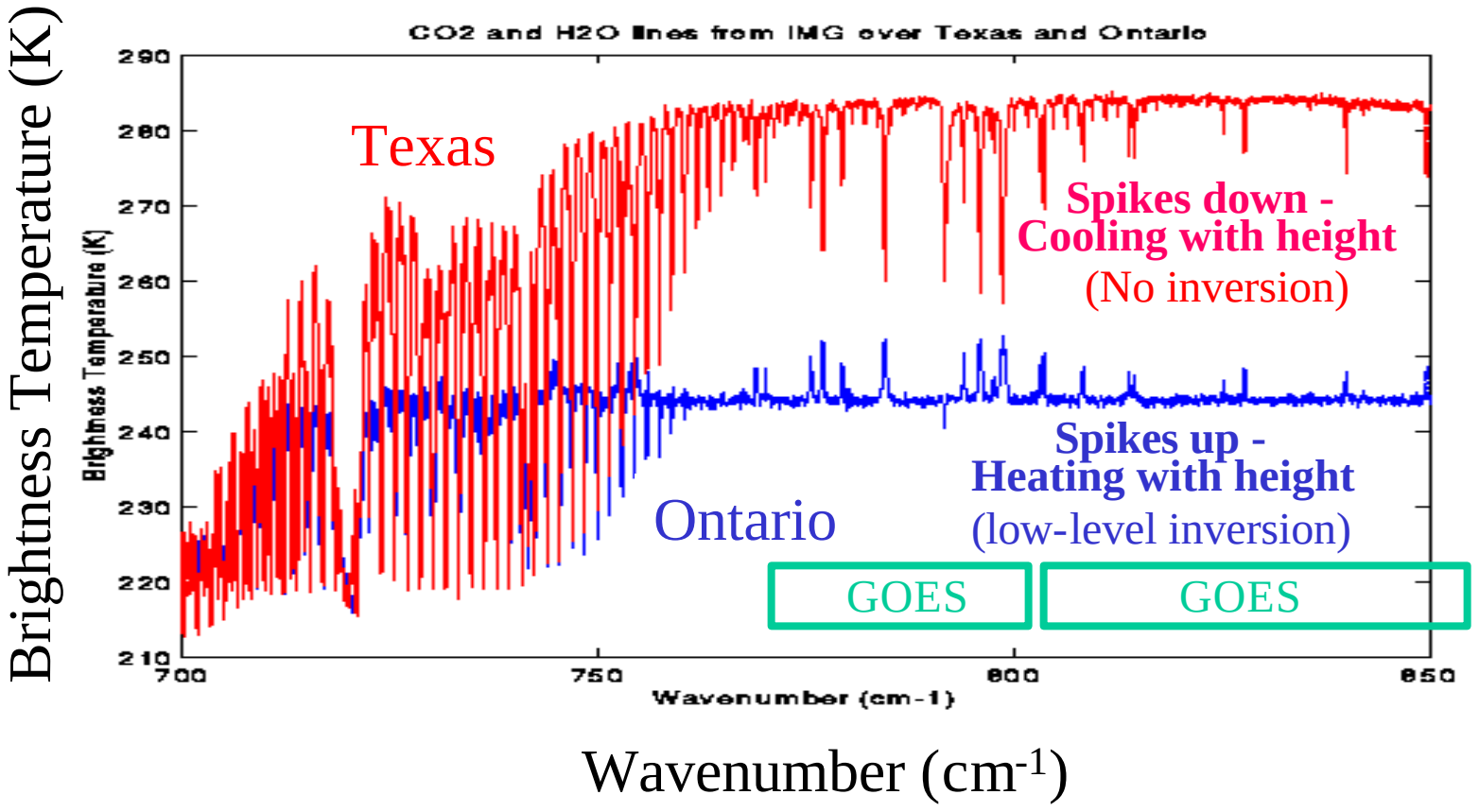


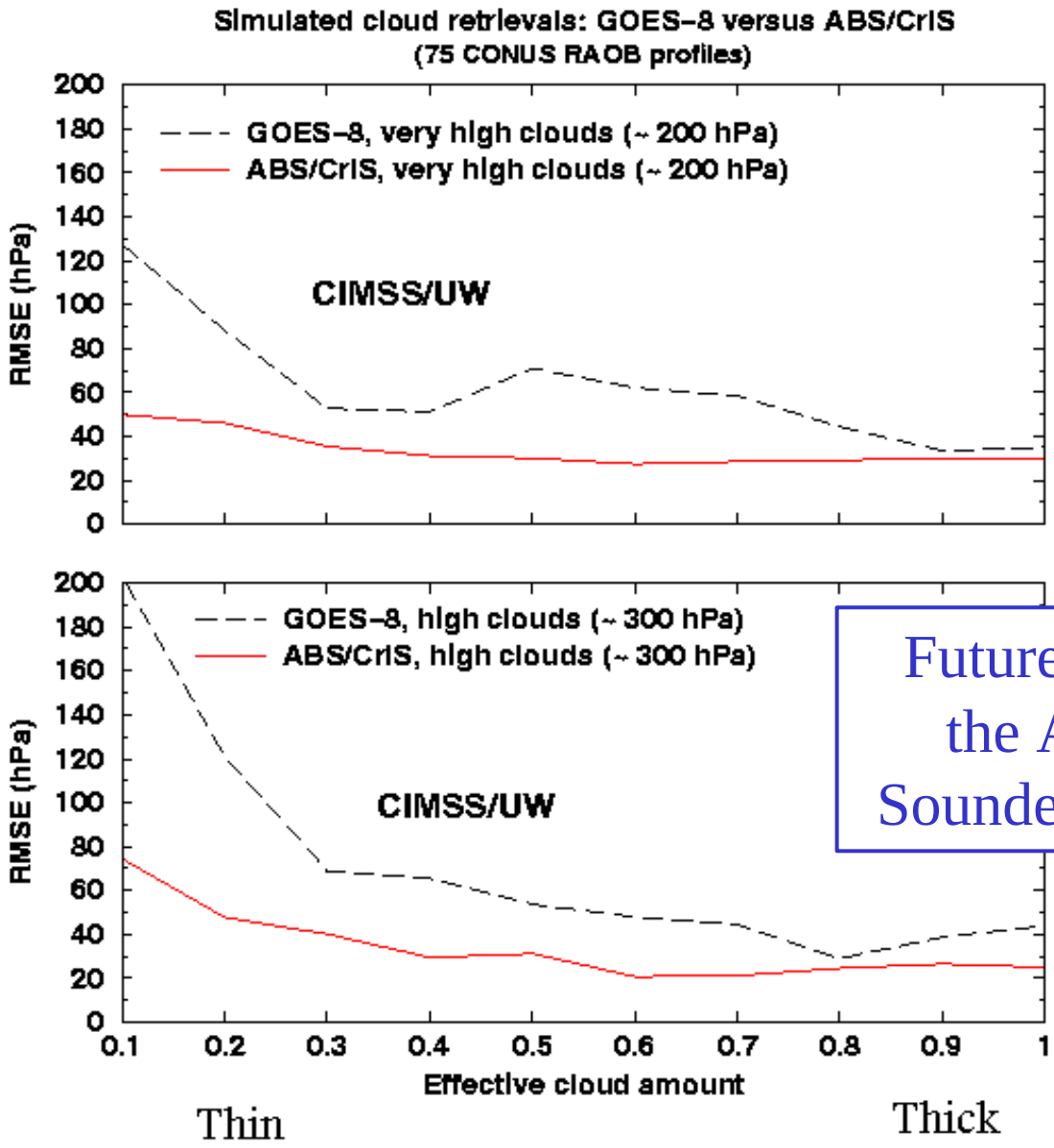
(UW/CIMSS)

Detection of Temperature Inversions Possible with Interferometer



Detection of inversions is critical for severe weather forecasting. Combined with improved low-level moisture depiction, key ingredients for night-time severe storm development can be monitored.

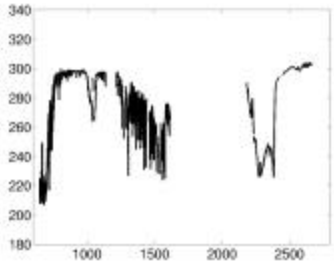
ABS/HES Cloud Top Pressure Retrieval



Future GOES -- simulating the Advanced Baseline Sounder (ABS) performance

(UW/CIMSS)

Summary -- HES



HES addresses NWS Imager concerns by:

- scanning faster
  - temporal sampling improved
  - more regions scanned
- adding spectral resolution
  - to improve the vertical resolution of the retrievals

Simulations show that the HES addresses NWS requirements for improved cloud, moisture, and surface products.

Every product that is being produced from the current GOES Sounder will be improved with data from the HES!

New products will be possible, especially when combined with higher temporal and spatial information from the ABI.